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Tax incentives for inefficient executive pay and reward for luck

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Abstract I study the economic consequences of tax deductibility limits on salaries for the design of incentive contracts. The analysis is based on an agency model in which the firm's cash flow is a function of the agent's effort and an observable random factor beyond the agent's control. According to my analysis, limiting the tax deductibility of fixed wages has two consequences. The principal rewards the agent on the basis of the observable random factor and adjusts the amount of performance-based pay in the optimal incentive contract. The new contract can have weaker or stronger work incentives than without the tax. The theoretical findings have implications for empirical compensation research. First, the analysis shows that reward for luck can be the optimal response to recent tax law changes, whereas earlier empirical literature has attributed this phenomenon to managerial entrenchment. Second, I demonstrate that a simple regression analysis that fails to control for separable measures of luck is likely to find an increased pay for performance sensitivity as a response to the introduction of tax deductibility limits on salaries even if the pay for performance sensitivity has actually declined.

Keywords Executive compensation · Agency theory · Relative performance evaluation

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Section 162(m) of the Internal Revenue Code limits the tax deductibility of executive compensation in publicly held corporations to $1 million per year. This "million-dollar tax cap" generally applies to the salary of the CEO and those of the

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next four highest compensated executives of the firm. Performance-based compensation is exempted from corporate taxation if it is paid on a commission basis or granted in accordance with a qualified bonus plan.[1]

The million-dollar tax cap was introduced in 1993 as a response to growing public concern about increasing executive pay. Advocates of the new tax rule seemed to believe that raising the cost of executive pay to shareholders would discourage firms from granting “excessive” compensation packages to their executives. Somewhat ironically, executive pay continued to grow considerably after the introduction of section 162(m). For example, the average total pay of S&P 500 CEOs rose from $2.6 million in 1993 to $14 million in 2000. Even after the burst of the stock market bubble in 2002, the average total CEO pay was $9.4 million. At the same time, the structure of executive pay has changed significantly during the past decade. In 1993, base salary accounted for 37% of the average total CEO pay, but by 2002 this portion dropped to 19%. This structural change was mainly driven by the increased use of stock options, which accounted for 24% of the average total CEO pay in 1993 as compared to 47% in 2002.[2]

The empirical evidence on the impact of section 162(m) on the level and the structure of executive pay is mixed. Perry and Zenner (2001) analyze a sample of firms affected by the million-dollar cap and find that real compensation levels have increased, mainly due to the grant of stock options. They also report a reduced salary growth rate and an increased pay for performance sensitivity. These results are supported by Hall and Liebman (2000), who identify a decline in salary that is more than offset by additional bonus payments and stock option grants.[3] On the other hand, Johnson et al. (2001) find an increased pay for performance sensitivity but they cannot attribute it to the introduction of section 162(m). Finally, Rose and Wolfram (2002) find that the million-dollar tax cap has created a focal point for the determination of salaries, but they find little evidence for a significant impact of section 162(m) on total compensation levels and the pay for performance relation.

Even if section 162(m) has encouraged firms to tighten the link between firm performance and executive compensation, it is not obvious that the modified pay structure has improved the executives’ work incentives. In particular, Bertrand and Mullainathan (2001) find that CEOs are frequently rewarded for luck. They define luck as “changes in firm performance beyond the CEO’s control” and use oil price movements, changes in exchange rates and mean industry performance to measure it. They explain their findings with the skimming hypothesis, according to which managers are able to set their own pay due to failures in firms’ governance structures.[4]

[1] For qualifying as “performance-based remuneration” a number of requirements must be met, see Balsam and Ryan (1996), or Balsam and Yin (2005) for details and illustrative examples of company practice.

[2] For more details, see e.g. Hall and Murphy (2003) or Jensen et al. (2004).

[3] Similar observations are reported in Rose and Wolfram (2000), Balsam and Ryan (2005a, b), who find an increased pay for performance relation for executives hired after the introduction of section 162(m).

[4] See Bertrand and Mullainathan (2000, 2001). The “skimming hypothesis” has been put forward by practitioners such as Crystal (1991) as well as by academics, such as Bebchuk and Fried (2003), who also refer to it as the “managerial power approach”.

Motivated by the mixed empirical findings, I study the consequences of tax deductibility limits on salaries for the design of incentive contracts. The analysis is based on a linear agency model in which the firm's cash flow is a function of the agent's effort and an observable random factor with positive mean. In the absence of tax restrictions, the observable factor is filtered out of the performance measure because it makes the contract riskier without providing better incentives.

Limiting the tax deductibility of salaries provides incentives for substituting a part of the agent's fixed wage by an increased amount of variable pay to minimize the corporate tax bill. I find that these incentives can significantly distort the structure of the optimal compensation contract. According to my analysis, a tax cap on salaries has two effects. First, it triggers reward for luck, and second, it provides incentives for adjusting the amount of performance-based pay. Intuition suggests that a fiscal discrimination of salaries would always result in an increasing amount of performance-based pay and thereby also boost the agent's equilibrium effort. Somewhat surprisingly, I find that this conjecture may be misleading. In my model, the agent's equilibrium effort can generally increase or decrease as a response to the introduction of the tax cap.

This result can be explained by the fact that changing the amount of variable pay has two countervailing effects. Augmenting the amount of variable pay increases the agent's expected remuneration, but it also increases the risk premium for which the principal must compensate the agent. If the principal wants the agent to accept a new contract with higher variable pay, he can only cut the salary if the marginal increase of variable pay is larger than the incremental risk premium. For the separable random factor, this condition is always met. It has a positive mean, and its marginal risk premium equals zero in the optimal contract in absence of the tax cap. Therefore, tying the agent's pay to this factor will always allow for a reduction of the agent's salary without violating his participation constraint. However, for the performance-based bonus, it may well be the case that the marginal risk premium is larger than the marginal increase of variable pay. If this condition is met, it is impossible to offer the agent an acceptable contract with increased incentives and a lower salary. Accordingly, the principal must simultaneously cut the salary and the amount of performance-based pay for reducing his tax due.

My paper extends recent work of Halperin et al. (2001). They consider a binary agency model with continuous effort but they do not consider the use of multiple performance measures, nor do they address the empirical phenomenon of reward for luck. However, in contrast to my analysis they find that the tax on fixed wages unambiguously raises the amount of performance-based pay. Intuitively, this conflicting prediction can be explained by the fact that the marginal risk premium is monotonically decreasing in the agent's equilibrium effort in the model of Halperin et al. (2001) but monotonically increasing in the linear agency model. In Sect. 4, I discuss the issue in detail. I also demonstrate that the substitution effect between performance-based pay and reward for luck can also be established in a binary agency model with discrete effort.

Based on my theoretical results, I discuss implications for empirical compensation research. First, I demonstrate that my model predicts a positive relation between the agent's pay and the separable random factor in the firm's cash flow. A one-to-one estimation of my theoretical model would support the findings of Bertrand and Mullainathan (2001) in an optimal contracting model without referring to managerial entrenchment. Second, I show that pay for performance regressions that fail to control for observable measures of luck are likely to find that the pay for performance sensitivity has increased as a response to section 162(m) even if it has actually declined. These findings underline the importance of controlling for separable measures of luck in empirical compensation research to avoid biased estimates of pay for performance sensitivities.

The rest of the paper is organized as follows. Section 1 explains the model assumptions. In Sect. 2, I derive the optimal incentive contracts with and without the tax constraint. Section 3 provides a detailed discussion of my theoretical results and their implications for empirical compensation research. Section 4 concludes.

1 Model assumptions

I consider a linear agency model with a risk-neutral firm owner (the principal) and a risk- and effort-averse manager (the agent), who runs the business on behalf of the owner. The firm's cash flow from operations comprises the agent's contribution and two different random factors beyond the agent's control. It is given by the following expression:

$$x = b \cdot a + c \cdot z + \varepsilon. \tag{1}$$

The variable a denotes the agent's effort and the parameter b, $b > 0$, measures the marginal impact of managerial effort on the firm's cash flow. The agent's effort is unobservable for the principal. The other cash flow components, z and ε, are the realizations of two independent, normally distributed random variables $\tilde{z}$ and $\tilde{\varepsilon}$, respectively. I assume that $\tilde{\varepsilon}$ has zero mean and variance σ_ε^2, and that $\tilde{z}$ has mean $E[\tilde{z}] = \mu > 0$ and variance σ_z^2.

The random variables $\tilde{z}$ and $\tilde{\varepsilon}$ represent the impact of uncontrollable events on the firm's cash flow. Splitting the random factors into two components allows me to distinguish between measurable and unmeasurable factors affecting cash flow from operations. I assume that $\tilde{z}$ is separately measurable but $\tilde{\varepsilon}$ is not. Illustrative examples for the measurable factor $\tilde{z}$ are input prices or foreign currency exchange rates. Similarly, if x is interpreted as the firm's stock price, $\tilde{z}$ can be interpreted as the stock price of a benchmark firm operating in the same industry or a stock price index. The impact of the observable factor on the firm's performance is captured by the parameter c. In general, c can take any sign, but for the ease of exposition I subsequently assume that $c > 0$. The impact of all other uncontrollable factors on the firm's cash flow, such as unexpected problems with large suppliers and customers, industry shocks, or political events, is captured by the random variable $\tilde{\varepsilon}$.

The agent is risk averse and dislikes to work hard. I assume that exerting effort causes personal cost of $C(a)$ on the part of agent. I assume that the cost function is monotonically increasing and convex in a, i.e. $C' > 0$, $C'' > 0$, where the dashes denote the first and second derivative of C with respect to a. For motivating the agent to work hard, the principal offers him a performance-based remuneration contract. A natural measure for evaluating the agent's performance is the firm's cash flow. To avoid rewarding the agent for good luck (or punishing her for bad luck) the principal evaluates the agent's performance relative to the realized value of the measurable random factor $\tilde{z}$. I assume that the principal offers the agent the following linear compensation contract:

$$s = w + v, \quad v = v_x \cdot x + v_z \cdot z, \tag{2}$$

where w denotes a fixed wage; v denotes the total of the agent's variable compensation; v_x is the bonus coefficient placed on cash flow; and v_z is the weight put on the realization of the measurable random factor $\tilde{z}$. To derive closed form solutions for the optimal compensation contract, I assume that the agent exhibits a negative exponential utility function with constant absolute risk aversion, $U(s(\cdot), C(a)) = -\exp^{-r[s(\cdot)-C(a)]}$. Combined with the assumption of normally distributed noise terms, this particular utility function allows for presenting the agent's objective function by his certainty equivalent.[5]

$$CEA = E[s] - C(a) - R(s), \quad R(s) = \frac{r}{2} \cdot \mathrm{Var}[s]. \tag{3}$$

The agent's certainty equivalent comprises his expected wage, his cost of effort $C(a)$, and the risk premium $R(s)$. The risk premium depends on the variance of the agent's compensation, Var[s] and the agents' coefficient of absolute risk aversion, r.

The critical element in my analysis is the consideration of a corporate tax on fixed wages. As in Halperin et al. (2001), I assume that fixed wages can only be deducted from the corporate tax bill up to an amount of $\overline{w}$. This assumption corresponds exactly to the one million-dollar tax cap in section 162(m) of the Internal Revenue Code. Assuming a corporate tax rate of τ, the principal's objective function can be stated as follows:

$$\Pi = (1 - \tau) \cdot (E[x] - E[s]) - \max\{0, \tau \cdot (w - \overline{w})\} \tag{4}$$

According to (4), the principal maximizes the difference between the expected cash flow and the agent's compensation after taxes. If he sets the fixed wage w above the tax limit of $\overline{w}$ he has to pay additional taxes of $\tau \cdot (w - \overline{w})$. I next analyze how the existence of the tax cap on fixed wages affects the design of the optimal compensation contract.

2 Optimal linear incentive contracts

2.1 Unconstrained solution

In this section, I present the standard solution of the model, assuming that the tax constraint does not bind. The principal maximizes his after-tax income in (4) subject to the following two constraints

[5] See e.g. Hemmer (2004), who also provides a critical assessment of the "LEN-model" and its limitations. The formal introduction of the model is frequently attributed to Holmström and Milgrom (1987) but at least the term "LEN-model" goes back to Spremann (1987).

$$a = \arg\max_{a^\circ} CEA = E[s] - C(a^\circ) - \frac{r}{2} \cdot \mathrm{Var}[s] \tag{5}$$

$$E[s] - C(a) - \frac{r}{2} \cdot \mathrm{Var}[s] \geq \underline{U}, \tag{6}$$

where $\underline{U}$ denotes the agent's reservation utility. The first constraint in (5) is the incentive constraint. It ensures that the principal correctly anticipates the agent's utility maximizing effort choice when designing his contract offer. The second constraint in (6) is the agent's participation constraint. It ensures that the agent weakly prefers to accept the contract instead of refusing it.

For determining the agent's optimal effort choice, I first evaluate the expectation and the variance of the agent's remuneration. For the contract defined in (2), I get:

$$E[s] = w + E[v] = w + v_x \cdot b \cdot a + (v_x \cdot c + v_z) \cdot \mu, \tag{7}$$

$$\mathrm{Var}[s] = v_x^2 \cdot \sigma_\varepsilon^2 + (v_x \cdot c + v_z)^2 \cdot \sigma_z^2. \tag{8}$$

Inserting the expressions in (7) and (8) into the agent's objective function in (3) and maximizing it with respect to a yields the following first order condition for the agent's effort choice:

$$v_x \cdot b = C'(a) \tag{9}$$

Condition (9) states that the agent's effort is determined by equating his expected marginal compensation with his marginal cost of effort, $C'(a)$. The optimal effort is decreasing in the agent's marginal cost and increasing in his productivity parameter (b) and in his personal share in the firm's cash flow (v_x). However, the agent's effort decision is independent of v_z because his action does not affect the realization of the separable random factor z.

Having all of the bargaining power, the principal designs the contract so that the participation constraint binds. Solving (6) for $E[s]$ and substituting the resulting expression into (4) yields a simplified objective function for the principal:

$$\Pi_u = (1 - \tau) \cdot (E[x] - C(a) - R(s) - \underline{U}). \tag{10}$$

The expression in (10) shows that the principal effectively maximizes the after-tax difference between the expected cash flow, the agent's cost of effort, the risk premium, and the agent's reservation utility. For determining the incentive weights of the optimal contract, I first recall that v_z does not affect the agent's effort choice but the variance of his compensation. Since the principal must compensate the agent for his compensation risk, he uses the weight on the realization of the measurable random factor for reducing the variance of the agent's pay. Minimizing (10) with respect to v_z yields the first order condition:

$$\frac{\partial \Pi_u}{\partial v_z} = -(1 - \tau) \cdot \frac{\partial R(s)}{\partial v_z} = 0. \tag{11}$$

It says that the principal sets v_z so that agent's risk premium is minimized. Solving (11) for v_z yields an incentive weight of

$$v_z^* = -c \cdot v_x, \tag{12}$$

so that the expressions for the expectation and the variance of the agent's pay in (7) and (8) reduce to:

$$E[s|v_z^*] = w + v_x \cdot b \cdot a, \quad \text{and} \quad \mathrm{Var}[s|v_z^*] = v_x^2 \cdot \sigma_\varepsilon^2. \tag{13}$$

According to (13), the principal entirely removes the effect of the separable random factor $\tilde{z}$ from the agent's compensation contract. This result can be interpreted as if the agent's performance was evaluated on the basis of the "filtered cash flow" $m = x - c \cdot z$. The performance measure m is less risky and therefore less costly for the principal than the gross cash flow though offering the same incentives for effort provision.[6]

Substituting the agent's first order condition from (9) and v_z^* from (12) into (10) and maximizing the resulting expression with respect to a yields the principal's first order condition for determining the optimal effort level:

$$\frac{b}{1 + r \cdot C''(a) \cdot \sigma_\varepsilon^2 / b^2} = C'(a). \tag{14}$$

To induce the desired effort level, the principal places the following incentive weight on the firm's cash flows:

$$v_x^* = \frac{C'(a)}{b} = \frac{b^2}{b^2 + r \cdot C''(a) \cdot \sigma_\varepsilon^2}. \tag{15}$$

The expression in (15) is the standard result for the optimal incentive weight in a linear agency model.[7] It says that the performance weight in the optimal compensation contract should increase in the agent's productivity (b) but decrease in his coefficient of absolute risk aversion (r), the slope of his marginal effort cost curve ($C''(a)$), and the variance of the underlying performance measure (σ_ε^2).[8] The more productive, less costly and less risk averse the agent, the higher should be the incentive weight in a compensation contract for a given risk in the underlying performance measure and thus the effort level desired by the principal. The same solution would obtain in a world without taxes. I conclude that a proportional corporate income tax does not affect the optimal contract structure as long as all parts of the agent's compensation package are fully tax-deductible.[9]

[6] This result follows from the informativeness principle established by Holmström (1979).

[7] See e.g. Hemmer (2004), or Christensen and Feltham (2005). A formal derivation of the optimal incentive weight can be found in the Appendix.

[8] Referring to the terminology of Banker and Datar (1989) b represents the sensitivity and $1/\sigma_\varepsilon^2$ the precision of gross cash flow as a signal for the agent's effort.

[9] See Fellingham and Wolfson (1985) for a general analysis of optimal contracting in the presence of income taxes.

2.2 Tax constrained solution

2.2.1 General considerations

In this section, I derive the optimal incentive contract for a binding tax constraint. From (4) and the fact that the agent's expected pay comprises the fixed salary and the expected amount of variable pay, that is $E[s] = w + E[v]$, the objective function of the principal can be written as:

$$\Pi_c = (1 - \tau)(E[x] - E[v]) - w + \tau \cdot \overline{w}. \tag{16}$$

From (16) a marginal increase of the fixed wage reduces the principal's wealth by the factor one. By contrast, a marginal increase of the agent's variable pay reduces the principal's wealth only by the factor $(1 - \tau)$ in expectation. In other words, the tax cap on the fixed salary provides incentives for replacing a part of the agent's flat pay by an increased amount of variable pay.

In the model, the principal has two options for increasing the amount of variable pay. First, he could raise the bonus coefficient placed on the firm's cash flow, and second, he could augment the bonus coefficient placed on the realization of the random factor $\widetilde{z}$. Since v_z^* is set to filter the separable noise from the firm's cash flow in a world without taxes, the second alternative would be equivalent to an incomplete filtering of the separable random factor $\widetilde{z}$ from the firm's cash flow.

A cursory evaluation of the two alternatives suggests raising v_x rather than v_z because the former method offers the benefit of providing improved work incentives, while the latter merely increases the compensation risk without affecting the agent's effort choice. However, this conclusion can be misleading because it ignores the relation between the base salary and the variable components of pay in the agent's compensation contract. In the optimal contract, the principal uses the salary to meet the agent's participation constraint. Solving (6) for w yields:

$$w = \underline{U} + C(a) + R(s) - E[v]. \tag{17}$$

Equation (17) defines the minimum salary for satisfying the agent's participation constraint. It comprises the reimbursements for the agent's reservation utility, his personal cost, and the risk premium minus the expected amount of variable pay. A closer inspection of the expression in (17) shows that changing the amount of variable pay has two countervailing effects. On the one hand, augmenting the amount of variable pay increases the agent's expected utility and reduces the minimum salary for meeting the participation constraint. On the other hand, raising the amount of variable pay increases the risk premium for which the principal must compensate the agent and requires a higher base salary for satisfying the participation constraint.[10]

Because the marginal risk premium is monotonically increasing in the amount of variable pay, the fixed salary can only be substituted by variable pay if the incremental increase of variable pay exceeds the incremental increase of the risk premium. Otherwise an increase of variable pay would require an increase of the

[10] These first-order effects apply to an increase of both bonus coefficients, v_x and v_z. As a second-order effect, however, an increase of v_x also increases the cost of effort, which is not the case for v_z.

fixed salary for satisfying the agent's participation constraint. More formally, replacing a part of the salary by variable pay is only feasible if the optimal bonus coefficients in (15) and (12) satisfy the following condition:

$$\frac{\partial w}{\partial v_i} = \frac{\partial R(s)}{\partial v_i} - \frac{\partial E[v]}{\partial v_i} < 0, \tag{18}$$

which says that the marginal change of the expected variable pay induced by a change of the bonus coefficient v_i, $i \in \{x,z\}$, must be larger than the marginal increase of the risk premium. Lemma 1 uses condition (18) for defining the feasible bonus coefficients, v_x and v_z, in the presence of the tax constraint:

Lemma 1 *Condition* (18) *is always satisfied for the unconstrained bonus coefficient* v_z^* but not for v_x^*.

Proof See Appendix.

From Lemma 1, the principal can always replace a part of the agent's salary by rewarding the agent on the basis of the separable random factor z without violating the agent's participation constraint. To see the intuition behind this result, recall that the marginal risk premium equals zero for $v_z = v_z^*$ from condition (11), whereas a marginal increase of v_z augments the agent's expected utility by $E[z] = \mu$. Accordingly, v_z can always be chosen so that the agent's expected utility is increasing. This utility difference allows the principal to cut the agents' salary for minimizing the corporate tax bill. By contrast, it is not always feasible to achieve the same end by increasing the weight placed on the firm's cash flow because the marginal risk premium evaluated at $v_x = v_x^*$ can be smaller or larger than the marginal increase of the agent's expected variable pay. This ambiguity explains why the salary is not automatically replaced by an increased amount of performance-based pay.

2.2.2 *Impact of salary tax cap on reward for luck*

For deriving the optimal incentive weight on z, I substitute the expression for w from (17) into the principal's objective function in (16) and maximize the resulting expression with respect to v_z. I obtain the following first order condition:

$$\frac{\partial \Pi_c}{\partial v_z} = \tau \cdot \frac{\partial E[v]}{\partial v_z} - \frac{\partial R(s)}{\partial v_z} = 0. \tag{19}$$

Increasing the bonus coefficient v_z has two effects on the firm's profit: A tax effect, represented by the first term in (19), and an insurance effect, represented by the second term in (19). The tax effect measures the marginal tax savings from replacing a part of the fixed salary by raising the amount of variable pay. Because variable pay is fully tax-deductible but salaries above $\overline{w}$ are not, the firm saves a fraction τ of each fixed salary dollar that is converted into variable pay. As explained above, the insurance effect represents the marginal cost of increasing the amount of variable pay in the agent's incentive contract. It is strictly negative because increasing the bonus coefficient v_z increases the risk premium for which the principal must reimburse the agent to satisfy his participation constraint.

A comparison with condition (11) shows that in a world without taxes (that is for $\tau = 0$) the insurance term disappears because the principal sets $v_z = v_z^*$ for minimizing the variance of the agent's pay. However, for $\tau > 0$ and $\partial R(s)/\partial v_z = 0$, the tax effect in (19) equals $\tau \cdot \mu > 0$. It follows that the tax constrained bonus coefficient must exceed the optimal bonus coefficient in the unrestricted incentive contract. Substituting the explicit solutions for the partial derivatives into (19) and solving for v_z yields the following closed form solution:

$$v_z^{**} = v_z^* + \delta, \quad \delta = \frac{\tau}{r} \cdot \frac{\mu}{\sigma_z^2}. \tag{20}$$

Comparing the optimal bonus coefficients with and without the tax constraint yields the following result:

Proposition 1 *A corporate tax on salaries provides incentives for rewarding managers for luck.*

Proof For a given incentive weight v_x placed on the firm's cash flow, $v_z^{**} > v_z^*$ from (20).

The tax deductibility limit for the fixed wage makes it attractive to replace a part of the agent's salary by reward for luck. The amount of this shift in the structure of the compensation contract depends on the magnitude of the parameter δ. Its size is determined by the tax rate (τ), the agent's coefficient of risk aversion (r), and the mean-variance ratio of the separable performance measure, $\tilde{z}$. It is more attractive for the principal to substitute part of the fixed wage with variable pay if the tax rate or the mean–variance ratio of the uncontrollable performance measure $\tilde{z}$ are high, or if the agent's risk aversion is low. A high tax rate makes the use of salaries more costly, while a low risk aversion and a high mean-variance ratio of $\tilde{z}$ make reward for luck cheaper. With the optimal incentive weight v_z^{**} the expectation and the variance of the agent's pay become:

$$E[s|v_z^{**}] = w + v_x \cdot b \cdot a + \delta \cdot \mu, \quad \mathrm{Var}[s|v_z^{**}] = v_x^2 \cdot \sigma_\varepsilon^2 + \delta^2 \cdot \sigma_z^2. \tag{21}$$

The components of the optimal compensation contract in (21) are different from those for the unconstrained solution in (13). For given values of w and v_x, raising the bonus coefficient v_z^* by the factor δ increases the agent's expected pay by the amount of $E[s|v_z^{**}] - E[s|v_z^*] = \delta \cdot \mu$ and the variance of pay by the amount of $\mathrm{Var}[s|v_z^{**}] - \mathrm{Var}[s|v_z^*] = \delta^2 \cdot \sigma_z^2$. As a consequence, the principal must pay the agent an additional risk premium of $\Delta R(s) = \frac{r}{2} \cdot \delta^2 \cdot \sigma_z^2$. Doing so reduces his tax bill by the amount of $\Delta T = \tau \cdot \delta \cdot \mu$. For the optimal value of δ in (20), the marginal increase of the risk premium equals the marginal tax savings, that is, $\delta \cdot r \cdot \sigma_z^2 = \tau \cdot \mu$.

2.2.3 Impact of salary tax cap on equilibrium effort

To explore the consequences of the tax constraint on the agent's equilibrium effort, I note that the agent's incentive constraint is not affected by the salary tax cap and substitute the agent's first order condition from (9) and the optimal incentive weight

v_z^{**} from (20) into (16). Maximizing the resulting expression with respect to a yields the desired effort level from the principal's perspective:

$$\frac{b - \tau \cdot (b - a \cdot C''(a))}{1 + r \cdot C''(a) \cdot \sigma_\varepsilon^2 / b^2 - \tau} = C'(a). \tag{22}$$

Using the agent's incentive constraint yields the optimal incentive weight placed on the firm's cash flow:

$$v_x^{**} = \frac{C'(a)}{b} = \frac{b^2 - \tau \cdot (b^2 - b \cdot a \cdot C''(a))}{b^2 + r \cdot C''(a) \cdot \sigma_\varepsilon^2 - \tau \cdot b^2}. \tag{23}$$

Evaluating the principal's first order conditions with and without the tax constraint in (14) and (22) yields the following result:

Proposition 2 *A corporate tax on salaries can increase or decrease the agent's equilibrium effort. If* (18) *holds for* $v_x = v_x^*$, *the agent's effort level increases. Otherwise the agent's equilibrium effort is decreasing in the salary tax.*

Proof See Appendix.

Proposition 2 renders more precisely the observation made in Lemma 1. It states that the impact of the tax constraint on the agent's equilibrium effort, or equivalently on the bonus coefficient placed on the firm's cash flow, is determined by condition (18). In particular, two cases can be distinguished.

Case 1: If $\partial w / \partial v_x < 0$, the marginal increase of the agent's expected variable pay caused by an increase of v_x exceeds the marginal risk premium. In this case, the principal replaces a part of the fixed wage by performance-based pay if the binding tax constraint makes it attractive to cut the agent's salary.

Case 2: If $\partial w / \partial v_x > 0$, the marginal risk premium exceeds the marginal increase of the agent's expected variable pay. In this case, the principal cannot increase the expected amount of variable pay without violating the agent's participation constraint. However, this does not mean that the principal cannot benefit from tax savings, but he must cut the performance-based part of pay to do so. In particular, marginally adjusting v_x for a given effort level results in a marginal profit change of $\partial \Pi_c / \partial v_x = \tau \cdot \partial E[v] / \partial v_x - \partial R(s) / \partial v_x < 0$. The expression is negative for $\partial R(s) / \partial v_x > \partial E[v] / \partial v_x$. Because the principal cannot increase his profit by increasing the performance-based bonus, the only way to benefit from the tax savings consists of a simultaneous reduction of the salary and the amount of performance-based pay.

2.3 A numerical example

In this section, I provide a numerical example to illustrate the two possible outcomes of the tax constrained incentive contract. The values in Table 1 have been computed for the quadratic cost function $C(a) = a^2/2$ and the following common parameter values: $r = 0.1$, $\sigma_\varepsilon^2 = \sigma_z^2 = 100$, $\mu = 500$, $c = 1$, a tax rate of $\tau = 0.4$, and a tax cap of $\overline{w} = 100$. To present illustrative examples for the two possible cases, I assume different parameter values for the agent's marginal productivity and

Table 1 Example results for the tax constrained LEN model

Case	v_x	δ	a	$E[x]$	$E[v]$	w	$R(s)$	Π_c
1a: $\Pi(v_x^*, v_z^*)$	0.615	0	24.62	1484.62	605.92	286.39	189.35	208.83
1b: $\Pi(v_x^*, v_z^{**})$	0.615	0.2	24.62	1484.62	705.92	206.39	209.35	228.83
1c: $\Pi(v_x^{**}, v_z^{**})$	0.727	0.2	29.09	1663.64	946.28	161.32	284.46	237.09
2a: $\Pi(v_x^*, v_z^*)$	0.385	0	9.62	740.38	92.46	227.74	73.96	129.02
2b: $\Pi(v_x^*, v_z^{**})$	0.385	0.2	9.62	740.38	192.45	147.74	93.96	149.02
2c: $\Pi(v_x^{**}, v_z^{**})$	0.333	0.2	8.33	708.33	169.44	140.84	75.56	150.50

the reservation utility. For the first scenario (labeled as cases 1a–c), I assume that $b = 25$ and $\underline{U} = 200$. For the second scenario (labeled as cases 2a–c), I assume that $b = 40$ and $\underline{U} = 400$. These values ensure that the tax constraint is binding for both cases.

Case 1a uses the unconstrained solution $(v_x^* = 0.615, v_z^* = -v_x^*)$ for solving the constrained agency problem. It serves as a benchmark for the first set of scenarios in which the salary and the performance-based bonus are substitutes in designing the agent's compensation contract and helps to illustrate the impact of increasing the bonus parameters v_z and v_x. Starting from the benchmark scenario, case 1b increases v_z by the factor $\delta = 0.2$ (recall that $v_z^{**} = v_z^* + \delta$). Because v_x is left unchanged, the agent's effort and the expected cash flow are unaffected by the introduction of reward for luck, but this adjustment causes a partial substitution of the agent's salary by an increased amount of variable pay. This change in the agent's pay structure increases the risk premium $R(s)$ and, more important, the after-tax profit Π_c.

In case 1c, the principal uses both options for alleviating the consequences of the tax cap by simultaneously increasing the two bonus coefficients v_x and v_z to their optimal levels. As a result, the agents' effort and the expected cash flow are increasing as compared with case 1b. In addition, the risk premium and the substitution between variable and fixed parts of pay are both reinforced. Evidently, the after-tax profit is higher as in case 1b because the principal implements the optimal solution of the tax constrained contracting problem.

Case 2a defines the benchmark for the second set of scenarios in which the salary and the performance-based bonus are complements in designing the agent's compensation contract. It uses the unconstrained solution $(v_x^* = 0.385, v_z^* = -v_x^*)$ for solving the constrained agency problem and helps to illustrate the impact of augmenting v_z and decreasing v_x. Case 2b leaves the performance-based bonus unchanged and introduces reward for luck into the agent's compensation contract. The consequences of this adjustment are qualitatively identical to case 1b.

The most interesting scenario is case 2c, where the principal simultaneously reduces the performance-based bonus and rewards the agent for luck. To isolate the impact of decreasing v_x, it is helpful to compare cases 2b and 2c because v_z is held constant in both. Clearly, a reduction of v_x reduces the agent's equilibrium effort and the expected cash flow. This undesirable effect is to some extent compensated by a reduction in the agent's total compensation, but the net profit before taxes is still declining. In particular, the expected cash flow decreases by the amount of

32.05 and the expected compensation (i.e. $E[v] + w$) decreases by the amount of 29.91, so that the net profit before taxes declines by 2.14.

However, the relevant measure for firm performance is the profit after taxes, which increases by the amount of 1.48 due to the structural change of the agent's compensation contract. The key is that a reduction of salaries above the tax cap of $\overline{w} = 100$ reduces the company's taxes by the factor $\tau = 0.4$. Adding the salary reduction of 6.90 and the gross profit reduction of 2.14 yields an overall reduction of the taxable profit by the amount of 9.04. Because the resulting tax savings of $9.04 \cdot \tau \approx 3.62$ are higher than the reduction of the pre-tax profit, the after-tax profit is higher than without a reduction of the performance-based bonus v_x.

The example underlines that the solution of the tax-constrained incentive problem depends on whether the salary and the performance-based bonus are substitutes or complements in designing the compensation contract. In the first case, the performance-based bonus is increasing; in the second case, it is decreasing. In both cases, the principal adds reward for luck to the optimal contract because reward for luck and the salary are always substitutes ($\partial w/\partial v_z < 0$). I conclude that the tax cap on salaries always causes at least one undesirable outcome.

3 Discussion of results and implications for empirical research

3.1 Discussion of the LEN model results

My analysis shows that limiting the tax deductibility of nonperformance-related pay can significantly distort the structure of optimal compensation contracts. The tax constraint makes wealth transfer between the principal and the agent more costly. As a direct consequence, a firm that would otherwise pay a fixed wage above $\overline{w}$ has an incentive to cut the agent's salary in response to the tax constraint. This direct effect corresponds to the intention of section IRC 162(m) and the empirical evidence provided by Perry and Zenner (2001) and Hall and Liebman (2000). Both studies report a decline in salaries but also find that the decline in salary is more than offset by an increased amount of performance-based compensation.

My theoretical results suggest that the observed substitution effect between flat and variable pay is more subtle than it seems at first glance. In my model, the tax deductibility limit has two separate effects.

- A part of the fixed wage is substituted by reward for luck.
- The actual amount of performance-based pay—that is, the bonus coefficient placed on the firm's cash flow—can increase or decrease with the tax constraint.

Taken together, these effects give rise to two different scenarios. In the first, the tax constraint induces reward for luck and an increasing equilibrium effort. In the second, the tax constraint induces reward for luck and a declining equilibrium effort. From a managerial perspective, both scenarios are undesirable because they reduce the firm's profit as compared with the unrestricted solution of the agency problem. From a regulatory perspective, however, the second scenario must be considered as the worse case because the tax constraint does not only provide incentives for increasing the amount of non-performance-based pay but also to cut the actual amount of performance-based pay.

In my linear agency model, reward for luck takes the form of incomplete filtering of a separate random variable in the firm's cash flow. Empirical compensation research has found that companies rather reward their executives for luck by using completely unfiltered performance measures instead of optimally adjusting them. Well known examples are the use of nonindexed stock and option grants (for example Hall and Murphy 2003). In the context of my model, this policy would be equivalent with setting $v_z = 0$, so that the agent's performance would be evaluated on the basis of the firm's cash flows.

To see if the firm can benefit from introducing reward for luck by means of unfiltered performance measures, I compare two extreme policies. The first consists of perfectly filtering the separable noise from the performance measure, and the second evaluates the agent's performance on the basis of the unfiltered cash flow. With full filtering (that is for $v_z = -c \cdot v_x$) the relevant performance measure is $m = x - c \cdot z$, so that the expected tax-constrained profit in (16) becomes

$$\Pi_f = (1-\tau)E[x] - C(a) - \underline{U} - \frac{r}{2}v_x^2 \cdot \sigma_\varepsilon^2 + \tau \cdot [v_x \cdot (E[x] - c \cdot \mu) + \overline{w}].$$

Without any filtering (that is for $v_z = 0$), the expected profit equals

$$\Pi_n = (1-\tau)E[x] - C(a) - \underline{U} - \frac{r}{2}v_x^2 \cdot \left(\sigma_\varepsilon^2 + c^2 \cdot \sigma_z^2\right) + \tau \cdot (v_x \cdot E[x] + \overline{w}).$$

For a given bonus coefficient v_x, the use of the unfiltered performance measure is strictly preferred if

$$\Pi_n - \Pi_f = \tau \cdot v_x \cdot c \cdot \mu - \frac{r}{2} \cdot v_x^2 \cdot c^2 \cdot \sigma_z^2 > 0. \tag{24}$$

Condition (24) compares the total tax savings from substituting a part of the salary by reward for luck with the additional risk premium associated with this policy. Whether condition (24) is satisfied depends on the relative magnitude of the parameters.[11] Rearranging terms in (24) shows that the unfiltered performance measure is preferred if $\delta > (v_x \cdot c)/2$, where δ is the optimal weight on z with partial filtering as defined in (20). I conclude that "no filtering" is more likely to dominate "full filtering" if reward for luck is a relatively important element in the optimal contract, so that the model predictions remain valid even if the firms do not practice partial filtering.

According to my analysis, a tax cap on salaries does not only provide incentives for rewarding luck but also affects the optimal amount of performance-based pay and thus the agent's equilibrium effort. In my model, the amount of performance-based pay can either decline or increase. As shown in Sect. 2, the direction of the change depends on the relative magnitude of the marginal changes in performance-based

[11] Condition (24) states that no filtering is preferred for an arbitrary incentive weight v_x if $\Pi_n(v_x) > \Pi_f(v_x)$. Because Π_n and Π_f are strictly concave in v_x, the same relation must also hold for the optimal bonus coefficients v_x^n and v_x^f because $\Pi_n(v_x^n) > \Pi_n(v_x)$ for all v_x including v_x^f, so that $\Pi_n(v_x^n) > \Pi_n(v_x^f) > \Pi_f(v_x^f)$.

compensation and the agent's risk premium. In particular, the principal can only make up a declining salary with an increased amount of performance-based pay if the marginal risk premium is smaller than the expected value of a marginal change in performance-based pay. Otherwise, he can only satisfy the agent's participation constraint by reducing the amount of performance-based pay.

In the linear agency model, the relation between the salary tax cap and performance-based pay is closely related to the structure of the optimal compensation contract, and the conditions under which the tax constraint becomes relevant for designing it. Evidently, the tax constraint can only become relevant if the salary in the unconstrained linear agency model is positive. Slightly rearranging terms in (17) and taking into account that $E[v|v_z^*] = v_x \cdot \partial E[v]/\partial v_x$, and $R(s|v_z^*) = (v_x/2) \cdot \partial R(s)/\partial v_x$ yields a positive salary if the following condition is met[12]:

$$\underline{U} + C(a) > v_x \cdot \left[\frac{\partial E[v]}{\partial v_x} - \frac{1}{2} \cdot \frac{\partial R(s)}{\partial v_x} \right]. \tag{25}$$

The unconstrained fixed wage is positive if the sum of the agent's reservation utility and his cost of effort is larger than the difference between his expected marginal compensation and half of the marginal risk premium. Figure 1 shows the relation between condition (25) and the condition determining the sign of the marginal rate of substitution between w and v_x in (18) as a function of the marginal rate of expected performance-based pay ($\partial E[v]/\partial v_x$):

If $\partial E[v]/\partial v_x < (\partial R(s)/\partial v_x)/2$, the right hand side of (25) is negative and w^* is unambiguously positive. If $\partial E[v]/\partial v_x > (\partial R(s)/\partial v_x)/2$, it is not clear if the salary in the unconstrained contract is positive or negative because both sides of (25) are positive. Similarly, the sign of $\partial w/\partial v_x$ is positive if $\partial E[v]/\partial v_x > \partial R(s)/\partial v_x$, and it is negative if the opposite is true. Taken together, these two relations suggest the following: an unambiguously positive salary in the unconstrained contract implies that w and v_x are complements. If w and v_x are substitutes, however, the sign of the unconstrained salary is ambiguous so that it is not clear if the tax constraint is binding because w^* can also be negative. It is therefore likely that $\partial w/\partial v_x > 0$ in those cases where the tax constraint affects the structure of the incentive contract, so

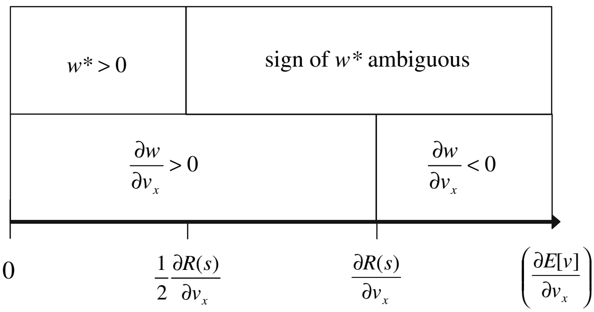

Fig. 1 The relation between the sign of w^* and $\partial w/\partial v_x$ in the linear agency model

[12] Note that for the unconstrained optimal contract, $v_z^* = -c \cdot v_x$ from (12), so that the expected amount of variable pay and the risk premium become $E[v|v_z^*] = v_x \cdot b \cdot a$ and $R(s|v_z^*) = \frac{r}{2} \cdot v_x^2 \cdot \sigma_\varepsilon^2$.

that the performance-based bonus is cut after the introduction of a tax cap on salaries.

Further insights into the relevant contract structure for a binding tax constraint can be gained by assuming a specific cost function that allows for deriving a closed form solution of the contract parameters. In particular, for a quadratic cost function of the type $C(a) = k \cdot a^2/2$ condition (25) becomes

$$\underline{U} > \frac{(v_x^*)^2}{2} \cdot \left(\frac{b^2}{k} - r \cdot \sigma_\varepsilon^2\right). \tag{26}$$

The sign of the right hand side of (26) depends on the sign of the term in brackets. With the quadratic cost function $a^* = v_x \cdot b/k$, so that $\partial w/\partial v_x = -v_x \cdot (b^2/k - r \cdot \sigma_\varepsilon^2)$. It follows that the sign of the expressions in (25) and (18) is determined by the same term.

Moreover, using the definition of the optimal bonus coefficient in (15), it can be shown that the term $b^2/k - r \cdot \sigma_\varepsilon^2$ is negative if $v_x^* < 1/2$ and positive if $v_x^* > 1/2$. The example shows that the sign of the fixed wage in the unconstrained contract usually depends on the size of the bonus coefficient. For small bonus coefficients, the fixed wage is always positive. If the bonus coefficient becomes larger, the sign of the salary depends on the agent's reservation utility. For the example cost function w^* becomes negative if $v_x^* > 1/2$ and $\underline{U}$ is normalized to zero, as is assumed in many agency models. The same effect can be seen in the example given in Sect. 2.3. For the first scenario (cases 1a–c), where the tax constraint induces an increasing equilibrium effort, $v_x^* = 0.615$, and for the second scenario (cases 2a–c), where the tax constraint implies a decreasing equilibrium effort, $v_x^* = 0.385$.

3.2 A binary agency model with reward for luck

The first key result of my paper is the insight that a tax cap on salaries induces reward for luck regardless of its impact on the agent's equilibrium effort. As mentioned in the introduction, Halperin et al. (2001) study the impact of tax distortions on the structure of executive pay in the context of a binary agency model, but they do not allow for tying the agent's compensation to a separable random factor. To complete the picture, it seems interesting to explore if Proposition 1 continues to hold in the context of a binary agency model.

To keep the analysis concise, I restrict my attention to the canonical version of the binary agency model with two different effort levels.[13] The model considers a risk-neutral principal and a risk- and effort-averse agent with an additively separable utility function $U(\cdot) - C(a)$, where $U'(\cdot) > 0$, $U''(\cdot) < 0$. The firm's cash flow equals $\widetilde{x} = \widetilde{y} + \widetilde{z}$, where $\widetilde{y}$ and $\widetilde{z}$ are independent binary random variables. I assume that both variables are separately observable and contractible. As in Sect. 1, the probability distribution of $\widetilde{z}$ is independent of the agent's effort, while the distribution of $\widetilde{y}$ depends on the agent's effort.

[13] See e.g. Christensen and Demski (2003), chapter 11.

Table 2 Distribution of cash flows and compensation in the binary agency model

x	$x_{HH} = y_H + z_H$	$x_{HL} = y_H + z_L$	$x_{LH} = y_L + z_H$	$x_{LL} = y_L + z_L$
$s(x)$	$w + b_y + b_z$	$w + b_y$	$w + b_z$	w
prob $(x\|a_H)$	$\pi \cdot p_H$	$(1 - \pi) \cdot p_H$	$\pi \cdot (1 - p_H)$	$(1 - \pi) \cdot (1 - p_H)$
prob $(x\|a_L)$	$\pi \cdot p_L$	$(1 - \pi) \cdot p_L$	$\pi \cdot (1 - p_L)$	$(1 - \pi) \cdot (1 - p_L)$

The agent's effort can take the values a_H and a_L, causing personal cost $C(a_H) = c_H$ and $C(a_L) = c_L$ with $a_H > a_L$, and $c_H > c_L$. The controllable part of the firm's cash flow, y, can take values y_H with probability p_H (p_L) and y_L with probability $1 - p_H$ ($1 - p_L$) if the agent exerts high (low) effort, where $y_H > y_L > 0$. The uncontrollable part of the firm's cash flow can take the values z_H with probability π and z_L with probability $1 - \pi$, where $z_H > z_L > 0$ so that $E[\tilde{z}] > 0$.

The bonus contract, $s(x)$, takes the following form: as usual for this model class, the agent receives a fixed salary w and a performance-based bonus, b_y if $\tilde{y} = y_H$. The novel element in my analysis is the additional bonus b_z that is paid if $\tilde{z} = z_H$. This second bonus is clearly not performance-based because the realizations of $\tilde{z}$ are independent of the agent's effort. The resulting distributions of the firm's cash flow and the agent's compensation are summarized in Table 2:

For addressing a nontrivial problem, I assume that the principal desires high effort, so that he maximizes his after-tax income

$$\Pi = (1 - \tau) \cdot \left[y_L + p_H\left(y_H - y_L - b_y\right) + E[z] - \pi \cdot b_z\right] - w + \tau \cdot \overline{w} \tag{27}$$

with respect to w, b_y, and b_z subject to the agent's participation and incentive constraints:

$$E[U_L] + p_H \cdot (E[U_H] - E[U_L]) - c_H \geq \underline{U}, \tag{28}$$

$$(p_H - p_L) \cdot (E[U_H] - E[U_L]) \geq (c_H - c_L). \tag{29}$$

Condition (28) assures that the agent accepts the contract and condition (29) that he chooses the desired effort level. The expressions $E\left[U_j\right] = E\left[U|y_j\right]$, $j \in \{L, H\}$, denote the agent's expected utilities from performance-based compensation for given realizations of the controllable random variable $\tilde{y}$. They are defined as follows:

$$E\left[U_j\right] = U(\omega_j) + \pi \cdot \left[U(\omega_j + b_z) - U(\omega_j)\right],$$

where $\omega_L = w$, and $\omega_H = w + b_y$. Assuming that the principal designs the contract so that both constraints bind, the optimal contract must satisfy the following two conditions:

$$E[U_L] = \underline{U} + c_H - p_H \cdot \frac{(c_H - c_L)}{(p_H - p_L)} \tag{30}$$

$$E[U_H] = \underline{U} + c_H + (1 - p_H) \cdot \frac{(c_H - c_L)}{(p_H - p_L)} \tag{31}$$

From (30) the agent's expected utility derived from compensation given that y_L is realized equals his reservation utility plus his cost of effort minus the expected bonus for a high performance. The bonus is measured in expected utility terms and equals $\Delta U = E[U_H] - E[U_L]$, so that $E[U_H] = E[U_L] + \Delta U$, and the agent's expected utility derived from the optimal contract equals $E[U] = (1 - p_H) \cdot E[U_L] + p_H \cdot E[U_H] = \underline{U} + c_H$.

If the tax constraint does not bind, b_z must equal zero because $\tilde{z}$ is neither controllable by the agent nor informative about his effort. As in the linear model, a bonus based on the realization of $\tilde{z}$ would increase the agent's compensation risk without providing additional incentives. Let s_1 denote the optimal unconstrained contract in a world without a discriminating taxation of salaries. With a salary of w_1 and a performance-based bonus of b_{y1} this contract causes an expected after-tax cost of $K(s_1) = (1 - \tau) \cdot (w_1 + p_H \cdot b_{y1})$ for the principal and yields an expected utility of $E[U(s_1)] = p_H \cdot U(w_1 + b_{y1}) + (1 - p_H) \cdot U(w_1)$ for the agent.

If the tax constraint is introduced and binding, the after-tax cost of contract s_1 jumps up to $\overline{K}(s_1) = K(s_1) + \tau \cdot (w_1 - \overline{w})$. This increase of the expected compensation cost provides incentives to offer the agent a new contract s_2 specifying a nonperformance-based bonus of $b_{z2} > 0$ and a lower salary to limit taxes. To make the agent indifferent between the old and the new contract, the new contract must satisfy that $E[U_L(s_2)] \geq U(w_1)$ and $E[U_H(s_2)] \geq U(w_1 + b_{y1})$. To meet these conditions, the principal sets the salary and the bonus so that $w_1 = w_2 + \pi \cdot b_{z2} - \rho_L$ and $b_{y2} = b_{y1} - (\rho_L - \rho_H)$, where

$$\rho_j = \omega_j + \pi \cdot b_{z2} - U^{-1}(E[U_j]), \quad j \in \{L, H\}, \tag{32}$$

is defined as the risk premium of the income lottery $L_j := [(1 - \pi) \cdot \omega_j, \pi \cdot (\omega_j + b_z)]$ that the new contract adds to the state contingent wealth levels $\omega_L = w_2$ and $\omega_H = w_2 + b_{y2}$. The first term in (32) is the expected value of the income lottery L_j, and the second term is the agent's certainty equivalent.

The principal's after-tax cost of the new contract are $\overline{K}(s_2) = K(s_2) + \tau \cdot (w_2 - \overline{w})$, where $K(s_2) = (1 - \tau) \cdot (w_2 + p_H \cdot b_{y2} + \pi \cdot b_{z2})$. For making the switch from s_1 to s_2 attractive, it must be that $\overline{K}(s_2) < \overline{K}(s_1)$ or, equivalently, that

$$K(s_2) - K(s_1) < \tau \cdot (w_1 - w_2). \tag{33}$$

Condition (33) requires that the tax savings associated with the adoption of contract s_2 must exceed the cost of increasing the agent's compensation risk under contract s_2. Substituting the definitions of $K(s_1)$, $K(s_2)$, w_2, and w_1 into (33) and rearranging terms shows that it is sufficient to set b_z so that it satisfies

$$b_{z2} > \frac{\rho_L + (1 - \tau) \cdot p_H \cdot (\rho_H - \rho_L)}{\pi \cdot \tau}$$

to reduce the expected compensation cost. Because b_z is not restricted, this condition can always be met without reducing the agent's expected utility. The intuitive cost comparison of alternative contracts with identical utility shows that the result in Proposition 1 is also valid in the context of a binary agency model.[14]

[14] A formal proof of this result is provided in the Appendix.

I next analyze whether the introduction of reward for luck affects the impact of the tax constraint on the agent's bonus. Consider again the move from contract s_1 specifying $b_{z1} = 0$ to contract s_2 with $b_{z2} > 0$. From the definition of the performance-based bonus, $b_{y2} = b_{y1} - (\rho_L - \rho_H)$, the introduction of reward for luck reduces the performance-based bonus whenever the risk premiums of the income lotteries L_L and L_H satisfy that $\rho_L > \rho_H$. Intuitively, the compensation contract s_2 adds an identical amount of noise to the utility levels derived from receiving the performance-based payments $U(w_2)$ and $U(w_2 + b_{y2})$. Comparing the risk premiums ρ_L and ρ_H is therefore equivalent to comparing a given lottery for the same individual with different levels of wealth. Because increasing wealth implies a nonincreasing risk premium it must be that $\rho_H \leq \rho_L$.[15] It follows that the performance-based bonus b_y is (weakly) decreasing in b_z. As in the linear agency model for the case where $\partial w / \partial v_x < 0$, there is a substitution effect between reward for luck and the performance-based bonus.

The following example illustrates the binary model with discrete effort and demonstrates that performance- and nonperformance-based bonuses can be substitutes in a binary agency model. The agent has utility function $U = \sqrt{s}$, the cost of effort are $c_H = 4$ and $c_L = 0$, and the corresponding probabilities for $y = y_H$ are $p_H = 0.8$ and $p_L = 0.4$. The reservation utility equals $\underline{U} = 10$, and the probability of receiving a nonperformance-based bonus equals $\pi = 0.5$. Table 3 exhibits six possible solutions for the contracting problem:

The benchmark solution is the optimal contract for a world without taxes (case 1). The optimal salary equals $w^* = 36$, the performance-based bonus is $b_y^* = 220$, and the expected cost is 212. If taxes are introduced but all compensation is tax deductible, the optimal solution is case 2. The contract parameters are not changed as compared with case 1 but the cost of compensating the agent drops to 169.6 because compensation is tax deductible. If the principal would deviate from the optimal solution and pay the agent a nonperformance-based-bonus of $b_z = 50$, the compensation cost jumps up to 170.7 because the principal must compensate the agent for the additional risk in his compensation (case 3).

Table 3 Solutions of the binary agency model for different contracting environments

Case	τ	$\overline{w}$	w	b_y	b_z	$K(s)$	Optimal
1: no tax, no tax cap, no reward for luck	0.0	none	36	220	0	212.0	yes
2: tax, no tax cap, no reward for luck	0.2	none	36	220	0	169.6	yes
3: tax, no tax cap, reward for luck	0.2	none	15	216	50	170.7	no
4: low tax with cap, reward for luck	0.2	10	11	214	64	171.6	yes
5: low tax with cap, no reward for luck	0.2	10	36	220	0	174.8	no
6: high tax with cap, reward for luck	0.4	10	10	206	98	128.7	yes

[15] This is a standard result in expected utility theory. It holds for most concave utility functions with strict inequality. An exception are exponential utility functions for which the risk premium is a constant. See e.g. Mas-Colell et al. (1995) for a formal proof.

In case 4, the tax cap becomes relevant. As a consequence the principal pays the agent a nonperformance-based bonus of $b_z^* = 64$, reduces the salary to $w^* = 11$, and the performance-based bonus to $b_y^* = 214$. Although the tax cap increases the compensation cost to 171.6, rewarding the agent for luck saves compensation cost as compared with case 5, where $b_z = 0$, and the expected compensation cost is 174.8. In case 6, the tax rate goes up to 0.4, and the salary is cut to the lowest reasonable value for tax saving purposes, that is, $w^* = \overline{w}$. Due to the increased tax rate, the amount of reward for luck increases to $b_z^* = 98$, and the performance-based bonus is cut further to $b_y^* = 206$.

So far, the binary agency model presented above confirms the main results of the linear agency model (for the case where $\partial w/\partial v_x < 0$), but it allows no prediction about the impact of the tax constraint on the agent's equilibrium effort. By contrast, Halperin et al. (2001) consider a binary agency model with continuous effort and find that the introduction of a tax cap on salaries causes an increasing bonus and raises the agent's equilibrium effort. This result is consistent with the first but not with the second part of Proposition 2. To explain the reason for this difference, I present the agent's participation constraint in Halperin et al. (2001) using the notation of the binary agency model above:

$$U_A = U(w) + a \cdot \big(U(w + b_y) - U(w)\big) - C(a) - \underline{U} \geq 0. \tag{34}$$

The expression in (34) is a slightly modified version of (28) for $\pi = 0$, where c_H is replaced by a strictly convex cost function $C(a)$ as in the linear agency model of Sect. 1, and the probability p_H is replaced by the agent's effort.[16] To see how a change of the agent's salary affects his bonus, I derive the marginal rate of substitution between w and b_y by totally differentiating the agent's participation constraint, using the fact that $\partial U_A/\partial a = 0$ from the agent's incentive constraint:

$$\frac{db_y}{dw} = -\frac{\partial U_A/\partial w}{\partial U_A/\partial b_y} = -1 - \frac{(1-a)}{a} \cdot \frac{U'(w)}{U'(w + b_y)} < 0.$$

The sign of the expression is negative for all possible effort levels, so that the salary and the bonus are substitutes for all feasible values of w and b_y. This observation shows why the result of Halperin et al. (2001) is not consistent with the second part of Proposition 2. A scenario where the salary and the bonus are complements in designing the agent's compensation contract as in the linear agency model cannot arise in the Halperin et al. (2001) setting.

Although the two model classes are not directly comparable in all details, the conflicting prediction regarding the agent's equilibrium effort can be explained by a closer inspection of the marginal risk premiums in both models. In the linear agency model, the conflicting prediction about the optimal contract in the presence of the tax constraint arises if the marginal risk premium exceeds the expected marginal amount of variable pay. This scenario is possible in the linear model because the marginal risk premium is increasing in the agent's equilibrium effort. In the model

[16] Because the agent's effort is modeled as a probability, a is restricted to take values between 0 and 1. See Halperin et al. (2001) for a detailed description of the model details, and the discussion of Sansing (2001) for numerical examples.

of Halperin et al. (2001), this case is excluded because the marginal risk premium is decreasing in the agent's equilibrium effort. In particular, the optimal contract specifies that $U(w) = \underline{U} + C(a) - a \cdot C'(a)$ and $U(w + b_y) = C'(a) - U(w)$, so that the agent's expected utility equals $E[U_A] = \underline{U} + C(a)$. The risk premium of the optimal contract equals

$$\rho = w + a \cdot b_y - U^{-1}(\underline{U} + C(a)), \tag{35}$$

where $w + a \cdot b_y$ is the expected amount of pay, and $U^{-1}(\underline{U} + C(a))$ is the certainty equivalent of the income lottery induced by the optimal contract. Because $C(a)$ is strictly convex, the second derivative of the expression in (35) with respect to a is negative, so that the marginal risk premium is decreasing in a, and the agent's marginal certainty equivalent is increasing in a. Accordingly, the principal can always substitute a part of the agent's salary by an appropriate increase of the bonus without reducing the agent's net utility if the tax constraint makes it attractive to do so.

3.3 Implications for empirical compensation research

The association between executive pay and firm performance is usually studied by regressing the amount of remuneration on various measures of firm performance. In my model, firm performance is measured in terms of the realization of the firm's cash flow. The agent's total remunerations with and without the tax constraint are given by the following expressions:

$$s^* = w^* + v_x^* \cdot m, \quad s^{**} = w^{**} + v_x^{**} \cdot m + \delta \cdot z, \tag{36}$$

where $m = x - c \cdot z$ is the realization of the filtered cash flow. A multiple regression of remuneration on filtered cash flow that controls for the separable random factor would take the general form

$$s = \beta_0 + \beta_m \cdot m + \beta_z \cdot z + \eta, \tag{37}$$

where β_0, β_m and β_z are the regression coefficients and η is the residual of the regression equation. For a world without tax deductibility limits on salaries, in which all firms would set compensation contracts according to s^*, my model predicts the following regression coefficients:

$$\widehat{\beta}_0^* = w^*, \quad \widehat{\beta}_m^* = v_x^*, \quad \widehat{\beta}_z^* = 0. \tag{38}$$

In a world with a tax on nonperformance-based compensation, however, firms would determine the parameters of their compensation contracts according to s^{**}, and the predicted regression coefficients would be as follows:

$$\widehat{\beta}_0^{**} = w^{**}, \quad \widehat{\beta}_m^{**} = v_x^{**}, \quad \widehat{\beta}_z^{**} = \delta. \tag{39}$$

A comparison of the regression coefficients in (38) and (39) shows that a one-to-one estimation of my theoretical model should yield a positive relation between the agent's pay and the separable random factor in the firm's cash flow. According to the definition of δ in (20), the regression coefficient $\widehat{\beta}_z^{**}$ should increase with the corporate tax rate τ and the mean-variance ratio of $\tilde{z}$ because both factors make wealth transfers based on $\tilde{z}$ relatively more attractive. A high tax rate raises the direct cost of salary-based wealth transfers, while a high mean-variance ratio of $\tilde{z}$ lowers the additional risk premium for rewarding the agent for luck.

Similar observations would be made if the firm rewarded the agent for luck by not filtering any noise from the performance measure instead of using a partial filtering strategy. In this case the optimal contract would be $s^n = w^n + v_x^n \cdot m + v_x^n \cdot c \cdot z$, and the predicted regression coefficients for the regression equation (37) would equal $\widehat{\beta}_m^n = v_x^n$ and $\widehat{\beta}_z = v_x^n \cdot c$.

The predictions of my model are consistent with the findings of Bertrand and Mullainathan (2001), who estimate the luck effect with a two-stage regression approach and attribute their findings to managerial entrenchment. Since my model predicts that $\widehat{\beta}_z^* = 0$ in the absence of tax constraints, it would be interesting to test the explanatory power of both theoretical explanations in a joint regression approach that controls for firm specific governance variables and for the firms' exposition to section 162(m) of the Internal Revenue Code.

My analysis further predicts that a multiple regression that controls for separable measures of luck should yield a smaller salary $(\widehat{\beta}_0^{**} < \widehat{\beta}_0^*)$ while the pay for performance sensitivity can either increase or decline $(\widehat{\beta}_m^{**} \lesseqgtr \widehat{\beta}_m^*)$ after the introduction of a tax on nonperformance-based pay. The first result is in line with Perry and Zenner (2001) and Hall and Liebman (2000), but the second result is only consistent with my theoretical analysis if the salary and the bonus are substitutes in designing the agent's compensation contract. One reason for this difference may be that these empirical studies have only considered firms in which the pay structures are so that $\partial w / \partial v_x < 0$. The second reason may be that the pay structures of the sample firms can be better captured by a binary model with continuous effort as in Halperin et al. (2001).

A third and less obvious explanation is that the sample firms in fact use linear contracts but that the empirical studies do not control for separable measures of luck in their regressions. In particular, assume that $\partial w / \partial v_x > 0$ in the unconstrained contract, so that the performance-based part of the agent's compensation declines. A pay for performance regression ignoring the possibility of reward for luck would estimate the pay for performance sensitivity according to the following regression equation:

$$s = \gamma_0 + \gamma_x \cdot x + \eta, \tag{40}$$

where γ_0 and γ_x are the regression coefficients. According to the results of my theoretical analysis, estimating Eq. 40 instead of Eq. 37 would yield the following pay for performance sensitivities in a world with and without a tax deductibility limit for nonperformance-based pay:

$$\widehat{\gamma}_x^* = v_x^* \cdot \frac{\sigma_\varepsilon^2}{\sigma_x^2}, \quad \widehat{\gamma}_x^{**} = \frac{v_x^{**} \cdot \sigma_\varepsilon^2 + c \cdot \delta \cdot \sigma_z^2}{\sigma_x^2}, \tag{41}$$

where the expressions in the numerators of (41) are the respective covariances between cash flow and total remuneration under the two different tax regimes, and $\sigma_x^2 = \sigma_\varepsilon^2 + c \cdot \sigma_z^2$ from the definition of x in (1).

Comparing the pay for performance sensitivities from the undifferentiated regression in (41) with those of the differentiated regression in (38) and (39) shows that the lack of control for separable measures of luck generally yields biased regression results. In particular, I find that $\widehat{\gamma}_x^* < \widehat{\beta}_m^*$ because $\sigma_\varepsilon^2 < \sigma_x^2$, and that $\widehat{\gamma}_x^{**} > \widehat{\beta}_m^{**}$ if $\delta - v_x^{**} > 0$. Thus, the expected pay for performance sensitivities from an undifferentiated regression will generally be biased downward in a world without tax-deductibility limits. With a tax cap on salaries the direction of the bias depends on the relative magnitude of reward for luck versus performance-based pay. The bias is positive, if the marginal reward for luck, δ, exceeds the weight on the firm's cash flow, v_x^{**}. Otherwise the bias is negative.

More important, if I compare the predicted results for the undifferentiated regressions with and without tax caps on salaries, I find that $\widehat{\gamma}_x^{**} > \widehat{\gamma}_x^*$ if $c \cdot \delta \cdot \sigma_z^2 > \left(v_x^* - v_x^{**}\right) \cdot \sigma_\varepsilon^2$. In other words, empirical studies are likely to find an increased pay for performance sensitivity as a consequence of section 162(m) although the pay for performance sensitivity has declined. From the definition of δ in (20) the critical condition for estimating a positive effect of section 162(m) on the pay for performance sensitivity can be rewritten as

$$c \cdot \mu > \left(v_x^* - v_x^{**}\right) \cdot \frac{r \cdot \sigma_\varepsilon^2}{\tau}. \tag{42}$$

Keeping the factors on the right hand side of (42) constant, wrongly estimating an increased pay for performance sensitivity is more likely if luck plays a relatively important role for firm performance (that is for large values of c and μ). Intuitively, it is much easier to confuse firm performance with the performance of the firm's management if firm performance is significantly affected by factors beyond the management's control.

4 Conclusion

This paper studies the consequences of tax deductibility limits on salaries for the structure of incentive contracts. The analysis is based on a linear agency model in which the firm's cash flow is modeled as a function of the agent's effort and an observable random factor. In the absence of tax restrictions, the observable random factor is filtered from the performance measure because it makes the contract riskier without providing better incentives. I demonstrate that the introduction of a tax-deductibility limit on salaries induces the principal to substitute part of the fixed wage by increasing the amount of variable pay. However, the increase of variable pay consists at least in part of a reward for luck, while the agent's work incentives can increase or decline as compared with the unconstrained incentive contract.

These results imply two different scenarios. In the first, the tax constraint induces reward for luck and an increasing equilibrium effort. In the second, the tax constraint induces reward for luck and a declining equilibrium effort. Both scenarios are undesirable from the firm's perspective because they reduce profit. From a regulatory perspective, however, the second scenario is clearly the worse case because the tax constraint provides incentives to substitute performance-based pay with reward for luck.

The theoretical results have important implications for empirical compensation research. First, my analysis predicts a positive relation between the agent's pay and the separable random factor in the firm's cash flow. Accordingly, reward for luck can be an optimal response to recent tax law changes, while earlier empirical literature has attributed this phenomenon to managerial entrenchment. Future empirical studies might reconsider the problem and provide evidence on the relative importance of the managerial entrenchment and the tax hypotheses.

Second, I show that a simple pay for performance regression that fails to control for observable measures of luck is likely to attribute an increased pay for performance sensitivity to the one-million-dollar tax cap although the pay for performance sensitivity has declined. These observations suggest that it is important to control for separable measures of luck in pay for performance regressions. Otherwise the empirical results will generally not provide reliable insights into the actual pay practices of firms.

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Appendix

1. Derivation of the unconstrained incentive weight (Eq. 15):

Substituting the results for the optimal effort and v_z^* from (9) and (12) into (10) yields

$$\Pi_u = (1-\tau)\cdot\left(b\cdot a + c\cdot\mu - C(a) - \frac{r}{2}\left(\frac{C'(a)}{b}\right)^2\cdot\sigma_\varepsilon^2 - \underline{U}\right).$$

Maximizing this expression with respect to a yields the following first order condition

$$\frac{\partial\Pi_u}{\partial a} = (1-\tau)\cdot\left[b - C'(a)\left(1 + r\cdot C''(a)\cdot\sigma_\varepsilon^2/b^2\right)\right] = 0.$$

Solving this condition for $C'(a)$ yields (14), and using the fact that $v_x = C'(a)/b$ from (9) yields (15).□

2. Proof of Lemma 1:

(a) Substituting the expression for the variance and the expectation of the agent's pay from (7) and (8) into (17) yields the optimal salary as a function of v_x and v_z

$$w(v_x, v_z) = \underline{U} + C(a) + \frac{r}{2}\cdot v_x^2\cdot\sigma_\varepsilon^2 + (v_x\cdot c + v_z)^2\cdot\sigma_z^2 - v_x\cdot b\cdot a - (v_x\cdot c + v_z)\cdot\mu.$$

Differentiating this expression and evaluating the solution for the unconstrained optimal contract parameters yields

$$\left.\frac{\partial w(v_x, v_z)}{\partial v_z}\right|_{v_x=v_x^*, v_z=v_z^*} = -\mu < 0 \tag{43}$$

$$\left.\frac{\partial w(v_x, v_z)}{\partial v_x}\right|_{v_x=v_x^*, v_z=v_z^*} = r \cdot v_x^* \cdot \sigma_\varepsilon^2 - b \cdot a \tag{44}$$

Since (43) is strictly negative, but (44) is positive if $r \cdot v_x^* \cdot \sigma_\varepsilon^2 > b \cdot a$, condition (18) is always satisfied for v_z^* but not for v_x^*. □

3. Proof of Proposition 2:

(a) Substituting the results for the optimal effort and v_z^{**} from (9) and (20) into (16) yields

$$\begin{aligned}\Pi_c = (1-\tau)(b \cdot a + c \cdot \mu) - C(a) - \frac{r}{2}\left(\frac{C'(a)^2}{b^2} \cdot \sigma_\varepsilon^2 + \delta^2 \cdot \sigma_z^2\right) \\ - \underline{U} + \tau \cdot (C'(a) \cdot a + \delta \cdot \mu + \overline{w}).\end{aligned}$$

Maximizing this expression with respect to a yields the following first-order condition

$$\begin{aligned}\frac{\partial \Pi_c}{\partial a} = (1-\tau) \cdot b - C'(a)\left(1 + r \cdot C''(a) \cdot \sigma_\varepsilon^2 / b^2\right) \\ + \tau \cdot (C''(a) \cdot a + C'(a)) = 0.\end{aligned} \tag{45}$$

Rearranging terms and solving this condition for $C'(a)$ yields the condition for the desired effort level, a^{**}, in (22).

(b) After rearranging terms, (45) can be written as follows:

$$\frac{\partial \Pi_c}{\partial a} = \frac{\partial \Pi_u}{\partial a} + \tau \cdot C''(a) \cdot \left[a - C'(a) \cdot r \cdot \sigma_\varepsilon^2 / b^2\right]. \tag{46}$$

Evaluating the expression in (46) at the unconstrained optimal effort level a^* yields

$$\left.\frac{\partial \Pi_c}{\partial a}\right|_{a=a^*} = \tau \cdot C''(a^*) \cdot \left[a^* - C'(a^*) \cdot r \cdot \sigma_\varepsilon^2 / b^2\right].$$

Evidently, $a^{**} > a^*$ if the term in brackets is positive, or, because $C'(a^*)/b = v_x^*$ from (9), if

$$b \cdot a^* > v_x^* \cdot r \cdot \sigma_\varepsilon^2. \tag{47}$$

Otherwise, $a^{**} < a^*$. Evidently, (47) is equivalent to (18) from (44). □

4. Proof of Proposition 1 for the binary agency model:

(a) The principal's problem consists of maximizing (27) subject to (28) and (29), which is equivalent to maximizing the following Lagrangian:

$$\begin{aligned}L =& (1-\tau) \cdot \left[y_L + p_H\left(y_H - y_L - b_y\right) + E[z] - w - \pi \cdot b_z\right] - \tau \cdot (w - \overline{w}) \\ &+ \lambda \cdot [E[U_L] + p_H \cdot (E[U_H] - E[U_L]) - c_H - \underline{U}] \\ &+ \mu \cdot \left[(E[U_H] - E[U_L]) - \frac{c_H - c_L}{p_H - p_L}\right].\end{aligned}$$

For given values of λ, μ, and b_y assume that $w > 0$ and $b_z = 0$, so that the Kuhn–Tucker-conditions are satisfied if

$$\frac{\partial L}{\partial w} = -1 + \lambda \cdot \frac{\partial E[U_L]}{\partial w} + (\lambda \cdot p_H + \mu) \cdot \left(\frac{\partial E[U_H]}{\partial w} - \frac{\partial E[U_L]}{\partial w} \right) = 0 \tag{48}$$

$$\frac{\partial L}{\partial b_z} = -\pi \cdot (1 - \tau) + \lambda \cdot \frac{\partial E[U_L]}{\partial b_z} + (\lambda \cdot p_H + \mu) \cdot \left(\frac{\partial E[U_H]}{\partial b_z} - \frac{\partial E[U_L]}{\partial b_z} \right) < 0, \tag{49}$$

where

$$\begin{aligned}
\frac{\partial E[U_L]}{\partial w} &= \pi \cdot U'(w + b_z) + (1 - \pi) \cdot U'(w) \\
\frac{\partial E[U_H]}{\partial w} &= \pi \cdot U'(w + b_y + b_z) + (1 - \pi) \cdot U'(w + b_y) \\
\frac{\partial E[U_L]}{\partial b_z} &= \pi \cdot U'(w + b_z) \\
\frac{\partial E[U_H]}{\partial b_z} &= \pi \cdot U'(w + b_y + b_z),
\end{aligned}$$

so that for $b_z = 0$

$$\begin{aligned}
\frac{\partial E[U_L]}{\partial b_z} &= \pi \cdot \frac{\partial E[U_L]}{\partial w} \\
\frac{\partial E[U_H]}{\partial b_z} &= \pi \cdot \frac{\partial E[U_H]}{\partial w}
\end{aligned}$$

substituting these expressions into (48) and (49) rearranging terms yields

$$\begin{aligned}
\lambda \cdot \frac{\partial E[U_L]}{\partial w} + (\lambda \cdot p_H + \mu) \cdot \left(\frac{\partial E[U_H]}{\partial w} - \frac{\partial E[U_L]}{\partial w} \right) &= 1 \\
\lambda \cdot \frac{\partial E[U_L]}{\partial w} + (\lambda \cdot p_H + \mu) \cdot \left(\frac{\partial E[U_H]}{\partial w} - \frac{\partial E[U_L]}{\partial w} \right) &< (1 - \tau),
\end{aligned}$$

a contradiction. I conclude that $b_z^* > 0$ □

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